Site Need Statement

General Reference Information	
1 *	***Need Title*:** Mixer Mobilization Pump Performance Prediction (formerly Solids Yield During Mixer Pump Mobilization)
2 *	***Need Code*:** RL-WT054
3 *	***Need Summary*:** Validated correlations or computational fluid dynamic models that can be used to predict the performance of mixer pumps as a function of definable waste properties and system configuration. The key performance measures of interest are the effective cleaning radius, time-varying vertical solids concentration profile, and most importantly, the amount of waste actually retrievable from the tank.
4 *	***Origination Date*:** FY 2000
5 *	***Need Type*:** Technology Need
6	***Operation Office*:** Office of River Protection
7	***Geographic Site Name*:** Hanford Site
8 *	***Project*:** Retrieval PBS No.: RL-TW04
9 *	***National Priority:*** ____1. High - Critical to the success of the EM program, and a solution is required to achieve the current planned cost and schedule. _X__2. Medium - Provides substantial benefit to EM program projects (e.g., moderate to high life-cycle cost savings or risk reduction, increased likelihood of compliance, increased assurance to avoid schedule delays). ____3. Low - Provides opportunities for significant, but lower cost savings or risk reduction, may reduce the uncertainty in EM program project success.
10	***Operations Office Priority*:** Medium
Problem Description Information	
11	***Operations Office Program Description*:** The overall purpose of the Retrieve and Transfer DST Waste function is to provide feed to the Waste Treatment Plant (WTP) and receive waste from SSTs. A primary objective of this function is to provide the tank farm infrastructure necessary to deliver waste to the WTP within established specifications. The baseline end state of the Retrieve and Transfer DST Waste function is: • Retrieval of all wastes from the DSTs • The safe, environmentally compliant transfer of this waste to the WTP • DSTs in a ready state for implementing closure and final disposal of the DST farms.
12	***Need/Problem Description*:** The basic need is to be able to predict the performance of mixer-pumps planned for deployment in DSTs at Hanford, based on physical properties of the waste, the mixer pump design parameters, and the overall configuration of the system (such as sludge depth, supernate depth, vertical and horizontal location of mixer pump discharge nozzles). This need was previously focused on accurate measurement of shear strength because of the perceived importance of shear strength to the ECR of a mixer pump. However, all of PNNL's mixer pump test data were recently correlated with three dimensionless parameters (Letter Report by Shekarriz et al. April 1998) with the following result: ECR is much more sensitive to nozzle velocity ($U_o^{0.75}$) than to shear strength ($1/\tau_s^{0.17}$). Shear strength appears to be less important than the characteristics of the jet. In full-scale mixer pumps, pumped slurry exits through a very short nozzle that may not create a well-developed jet, while small-scale mobilization tests used a nozzle that created a well-developed jet. It isn't clear if the current mixer pump design produces jets that are analogous to the small-scale tests, and consequently, the validity of using the correlations to predict full-scale performance is in question. Recent computational fluid dynamic modeling completed for tank AZ-102 (PNNL-13275) predicts that only 50% of the sludge present in that tank will be mobilized by operating two, 300-hp mixer pumps according to

	current baseline plans. This is significantly less than the currently planned retrieval efficiency of 80% (HNF-SD-WM-SP-012, Rev. 2, p. 4-2). The 80% retrieval efficiency is based on the best available ECR correlation. In FY 2000, a process test of the two, 300-hp mixer pumps in AZ-101 (RPP-6548 Rev 1) found that 95-100% of the waste was mobilized, however, an accurate unbiased estimate of the amount of waste suspended (and therefore the retrieval efficiency) could not be accurately determined. The planned retrieval efficiency for AZ-101 was 90%. ** **Program Baseline Summary (PBS) No.:** TW04 ** **Work Breakdown Structure (WBS) No.:** 5.02.02.01.04 ** **TIP No.:**
13	***Functional Performance Requirements*:** Mixer pump performance correlations and computational fluid dynamic modeling (TEMPEST) need to predict the performance of the actual pump design deployed under actual tank waste retrieval conditions (i.e., actual tank demonstrations). Correlations and models should consider current mobilization and pump data from Hanford, Savannah River Site and any other sites and allow designers to successfully address required mobilization, suspension, and retrieval efficiency performance. Increasing the accuracy of the predictions also requires reliable physical property information for the waste being retrieved. More accurate predictions of mixer pump performance would reduce the uncertainty with mixer pump performance. If mixer pumps are not as efficient at retrieving the waste as anticipated, alternative or supplemental approaches to retrieval may need to be pursued. These alternatives could include supplemental mixing, additional feed tanks, or modifying pump design needs and retrieval strategies to be consistent with actual sludge mobilization performance. Project W-211 has numerous scale model tests and theoretical analysis on which to base the mixer pump design. Further lab work does not seem prudent. The Pacific Northwest National Laboratory (PNNL) report referenced above (i.e., Letter Report by Shekarriz et al. April 1998), which was funded by Project W-211, did conclude differently than previous effective cleaning radius (ECR) correlations. However, it did not conclude that the pumps currently in the project are inadequate. Validation of the ECR correlation's and computational fluid dynamic models (TEMPEST) should use the results from the Tank AZ-101 mixer pump process test (RPP-6548 Rev 1) Confidence in the results of the computational fluid dynamic model (TEMPEST) could be increased by seeing if the model can predict the results of the AZ-101 mixer pump test as documented in RPP-6548 Rev 1 with respect to mobilization, suspension, and settling. With appropriate input data, the model could then be used to predict the performance of mixer pumps in other high-level waste tanks. A better understanding of conditions (primarily the time varying solids concentration field) inside the tanks during and after mixer pump operation is required to refine the retrieval strategy and to estimate retrieval efficiency. **Outsourcing Potential:** DOE complex only.
**	**Schedule Requirements:** This needs to be resolved so it can influence design updates to the high-level waste tanks. Key dates for the various high-level waste tanks are as follows: Tank — Start of Design — Start of Construction AZ-101 — FY2001 — FY2002 AZ-102 — FY1999 — FY2005 AY-102 — FY2001 — FY2006 AY-101 — FY2001 — FY2008 SY-102 — FY2007 — FY2010 (Project W-521) Early results (i.e., a validated model) will allow for better management of the programmatic risks with respect to the quantity of HLW feed that can be delivered to the Waste Treatment Plant.
14	***Definition of Solution*:**
15 *	***Targeted Focus Area*:** Tanks Focus Area (TFA)

16	***Potential Benefits*:** There is considerable uncertainty in the planning assumptions used to set the timing of the construction projects that provide the mixing and retrieval systems for delivery of HLW slurry feed to the Waste Treatment Plant. A more accurate estimate of the amount of feed that can be retrieved and delivered from each tank will allow for refinements in the project schedules. Schedule float may be identified and freed up for other uses in instances in which the planning assumptions turn out to be pessimistic. On the other hand, early mitigating actions (such as more mixers, acceleration of project schedules, identification of backup feed sources) can be taken in instances in which the planning assumptions turn out to be optimistic. Understanding the time-varying solids concentration profiles will help refine the estimates of the amount of feed that can be delivered (discussed above) and ensure that an effective process control strategy for the mobilization, suspension, and delivery of feed to the Waste Treatment Plant can be implemented with the current retrieval system designs.
17 *	***Potential Cost Savings*:** Up to $100M in cost avoidance.
18 *	***Potential Cost Savings Narrative*:** This is a risk (potential loss x probability) mitigating activity. The size of the potential loss is large if the retrieval efficiencies of the high-level waste tanks are significantly less than planned. The potential loss could be as large as the $100M in capital costs associated with the retrieval system projects if major rework is required plus the schedule and financial impacts of delaying high-level waste vitrification at the Waste Treatment Plan.On the other hand, some moderate cost savings may be realized if there is design conservatism that can be reduced for future pump installations.
**	***Technical Basis*:** Current equations for calculating mobilization efficiency have never been validated for actual conditions during full-scale retrieval. Additionally, correlations or model results for solids suspension, and to some degree settling, are not available. Timing of construction projects requires an accurate estimate of the amount of waste that can be retrieved from each tank and delivered to the Waste Treatment Plant. This timing is currently based on an unvalidated ECR correlation, which neglects solids suspension and settling behavior. Solids suspension and settling data is required to ensure that the retrieval and process control strategies will be effective. **Other:** Remove uncertainty pertaining to DOE's readiness to deliver the required volume of feed to the Waste Treatment Plant.
19	***Cultural/Stakeholder Basis***: N/A
20	***Environment, Safety, and Health Basis*:** N/A
21	***Regulatory Drivers*:** N/A
22 *	***Milestones*:** This activity supports the objective of treating 10% of the Hanford tank waste by mass and 25% by curies by 2018.
23 *	***Material Streams*:** Sludge, salt, liquid (RL-HLW-20) ID-2113 Sludge, Salt, Liquid Risk Score: 3 ID-2857 HLW to Treatment Risk Score: 3
24	***TSD System*:** Double Shell Tank systems
25	***Major Contaminants*:** Pu-238, 239, 240, 241; AM-241; U-238; C-14; Ni-59/63; Nb-94; Tc-99; I-129;Cm-242; Sr-90; Cs-137; Sn-126; Se-79; chromium; nitrate; nitrite; complexants (EDTA/HEDTA)
26	***Contaminated Media*:** Tank waste consisting of high molarity sodium hydroxide/sodium nitrate solution containing saturated saltcake and/or sludge.
27	***Volume/Size of Contaminated Media*:** All double shell tanks are 75 feet in diameter, and about 40 feet deep, with their tops buried about 10 feet below the ground surface.
28 *	***Earliest Date Required*:** Fiscal Year 2002
29 *	***Latest Date Required*:** September 2005
Baseline Technology Information	
30	***Baseline Technology/Process*:** Correlations derived from small-scale mobilization testing and a computational fluid dynamic model (TEMPEST), neither of which has been compared to full-scale tests.

	Technology Insertion Point(s): N/A
31	***Life-Cycle Cost Using Baseline*:**
32	***Uncertainty on Baseline Life-Cycle Cost*:**
33	***Completion Date Using Baseline:***
Points of Contact (POC)	
34	***Contractor End User POCs*:** P.J. (Paul) Certa, NHC, 509-376-5429, Paul_J_Certa@rl.gov
35	***DOE End User POCs*:** E.J. (Joe) Cruz, DOE-PRD, 509-372-2606, F/509-373-1313, E_J_Cruz@rl.gov
36 *	***Other Contacts:*** K.A. (Ken) Gasper, CHG, 509-371-3607, F/509-371-3504, Kenneth_A_Ken_Gasper@rl.gov

*Element of a Site Need Statement appearing in IPABS-IS
**Element of a Site Need Statement required by CHG